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RAE TECHNICAL NOTE No: GAS 26

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ROYAL AIRCRAFT ESTABLISHMENT

Farnborough, Hants.

THE USE OF ROCKET-PROPELLED FLYING MODELS FOR EXPERIMENTS AT TRANSONIC SPEEDS

by

THE STAFF,

GAS DYNAMICS DEPT., R.A.E.

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R.A.E. Tech. Note No. Gas 26

June, 1946

ROYAL AIRCRAFT ESTABLISHMENT, FARNBOROUGH

The Use of Rocket-Propelled Flying Models for Experiments at Transonic Speeds

by

The Staff of Gas Dynamics Dept.

R.A.E. Ref: Gas/3200/RS/29

SUMMARY

A brief description is given of the work now in progress on rocket-propelled flying model aircraft, aimed at obtaining aerodynamic data near the speed of sound. Future developments and application of the technique are discussed broadly.

Rocket-propelled flying models have more potential utility in this field than any other method suggested up to the present, apart from flight tests of full-scale aircraft. Their chief advantage is in the fact that they permit stability and control problems to be investigated as well as providing drag and lift data. Their only limitation is that, like full-scale aircraft, they must be designed to fly over the whole speed range, which may exclude some configurations of theoretical interest.

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1 Introductory

Several methods have been suggested for obtaining aerodynamic data near the speed of sound, in the speed range which cannot at present be covered by wind-tunnel techniques. The present note is one of a series prepared to review those various methods; it describes briefly the proposal to investigate the transonic speed range by rocket-powered model aircraft, released from a parent aircraft at high altitude, and observed by radio and radar methods. Active work on this scheme has been initiated by D.G.S.R's Supersonic Committee, with Vickers-Armstrong Ltd. designing and producing the models.

2 Present Technique

As a first design of model upon which to develop the experimental technique, 1/3rd. scale models of the Miles E24/43 are being constructed. They are to be propelled by a bi-fuel rocket - hydrogen peroxide and ethyl alcohol - developed at R.A.E. from similar German designs. The rocket motor was designed for a nominal 800 lb. thrust (it has already given over 900 lb.) and sufficient fuel is stored in the model to operate it for 65 seconds. It is proposed to carry the model to 36,000 ft. in a Mosquito aircraft, and to release it so that it will accelerate in roughly level flight at 35,000 ft. Anticipating results on the drag of the model, it is estimated that the thrust will then be sufficient to reach a maximum Mach number of 1.33 at the end of the burning period.

A section of the model, showing the location of propulsion unit, tanks, and instruments, is given in Fig.1, which includes a few major dimensions. Fig.2 shows the estimated behaviour during the flight.

The model will be kept on a straight course in roughly level flight by a small auto-pilot, very similar to that used in the German V1 weapon, but modified as described in para.3 below to cater for the very high speeds. This will operate on control surfaces which are exact models of those proposed for the full-scale aircraft, so that apart from scale-effect the control forces will be a measure of those actually demanded from a human pilot, and any mis-behaviour of the model will be significant in its application to the full-scale aircraft.

The chief source of information on the model's characteristics will be a six-channel telemetering equipment recording continuously six independent quantities at a nearby ground station. In the first tests, these will probably be:-

Stagnation pressure }
Static pressure } to give speed, height, Mach number.

Longitudinal acceleration }
Rocket thrust or chamber pressure } to give drag of the model.

Normal acceleration — to give lift coefficient, and to indicate any longitudinal hunting of the aircraft.

Tailplane angle or tailplane operating load (an all-moving tailplane is proposed on E24/43) to indicate the magnitude of any changes in longitudinal trim.

In later tests alternative instruments transmitting lateral and directional characteristics can be fitted. In addition to the telemetering equipment, it is proposed to track the model by ground radar.

As the model travels nearly 20 miles in the interesting range of Mach number, however, it is not expected that this type of tracking will give very accurate data. Its chief utility will be in checking the static pressure recorded by telemetering; an alternative check here is very desirable as there is no way of calibrating the model's static tube near the speed of sound on the ground.

The first flights will be made over the sea off South Cornwall, in the interest of safety, using radio and radar ground stations on the Scilly Isles.

3 Future Developments

It is clear that if the technique can be developed successfully, its potentialities are very great. In the extent of the information which can be derived from it, it falls little short of tests of a full-scale aircraft with a human pilot. With the present instruments, it is true, the amount of data is limited to 6 independent quantities per flight, and the model is unable to execute violent manoeuvres or aerobatics (or so it is hoped!). Modifications to extend the application in this way are clearly feasible, however, when the need arises. Anticipating successful development, a note[1] has already been prepared indicating possible future types of model.

The upper limit of Mach number, 1.33 on the first model, will increase as better supersonic designs, giving smaller peak drag coefficients at higher Mach numbers by application of sweepback principles, are produced and tested. It can also be increased by adding more fuel or flying at greater altitudes. There is, however, little point in further increase, as present supersonic wind-tunnels can give data at Mach numbers of 1.2 and above.

Probably the chief limitation on the use of the technique arises from the fact that it is so similar to flight-testing the full-scale aircraft, that the model must be designed, like the full-scale aircraft, to have everything as nearly right as possible. For example, the low-speed qualities cannot be sacrificed completely, as is possible in a wind-tunnel experiment, when exploring the transonic range; the model is launched at a speed not greatly above its stalling speed, and it must be able to fly reasonably well there. Similarly, there are likely to be longitudinal stability and trim changes in the transonic range, and it is essential to minimise these. The auto-pilot has been provided with powerful control servos so that the probable nose-down moment and large stability increase can be dealt with; but there is clearly an upper limit to the degree of correction which can be expected from the auto-pilot. It is possible that the first model, the E24/43, will encounter difficulty here, as although its longitudinal trim change is small, its longitudinal stability increases greatly at supersonic speeds (by over 0.5 chord movement of neutral point). There are reports of misbehaviour of a similar U.S. project, the "Private", when transonic speeds are reached, which confirm the need for attention here; full data on these American experiments, however, is not yet available.

From this point of view, the greatest potential utility of the rocket-model technique is in making advance tests of the overall behaviour of new aircraft designs intended for the transonic speed range, thereby removing a little of the considerable risk at present attaching to the first flights of such aircraft. For the present, however, its chief application will be the collection of more fundamental data on transonic characteristics, particularly from the

[redacted]

stability and control aspects which cannot be dealt with by the simpler dropped-body method.

Reference

No.	Author	Title, etc.
1	E. Simpson	Note on future possible designs of experimental transonic model. R.A.E. Tech. Note Gas 15, April 1946.

Circulation

D.G.S.R.	
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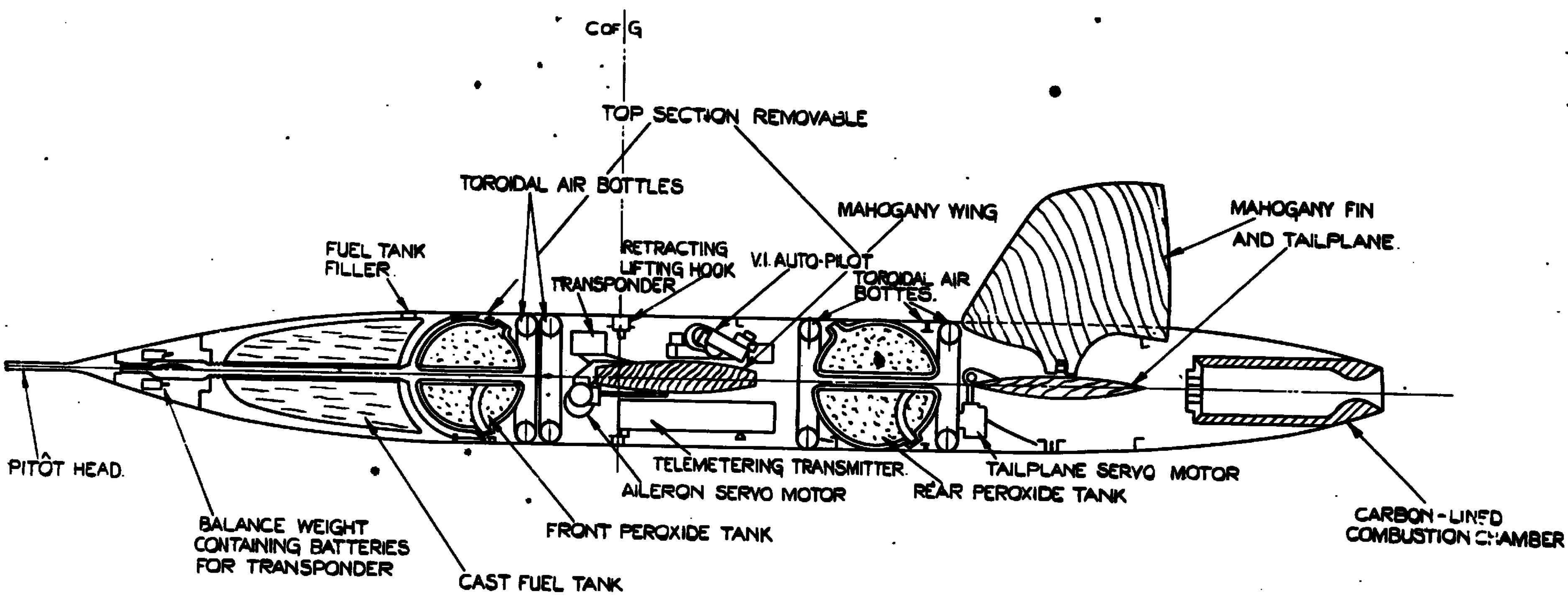
FIG. 1



VICKERS TRANSONIC ROCKET MODEL

Nº GAS 5705

VICKERS TRANSONIC ROCKET A/C. - RELEASE AT 350 KNOTS AT 36000 FT.

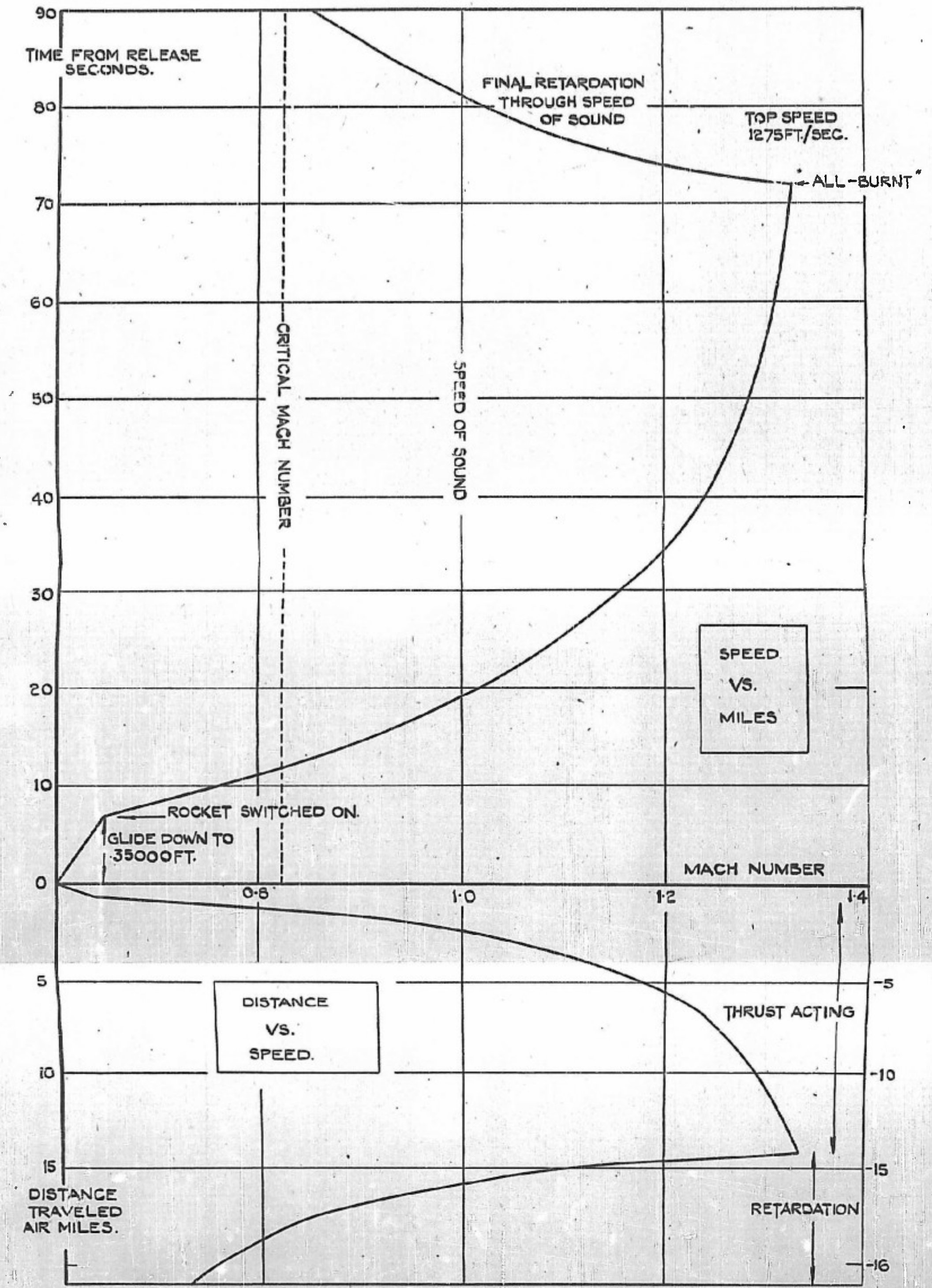


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FIG. 2

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AUTHOR(S)

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ABSTRACT

A proposal is made to investigate the transonic speed range by means of a liquid-rocket-propelled guided missile. This guided missile is launched from an airplane at high altitude and is observed by radio and radar. A brief description of the guided missile is given. The future development of this experimenting method is discussed. A drawing illustrates a longitudinal projection of the transonic guided missile and curves illustrate its estimated performance during flight.

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